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NOBEL PRIZE in PHYSICS

WILLIAM S. RODNEY, Nuclear Physics Division, AFOSR

The recent award of the Nobel Prize for Physics to Professor Robert Hofstadter of Stanford University was of special interest to the Air Force Office of Scientific Research. For some years, AFOSR has engaged in joint sponsorship, together with the Office of Naval Research and the Atomic Energy Commission's Physics Research Division, of the construction and operation of the electron linear accelerator at Stanford. The prize was awarded for Dr. Hofstadter's experiments which revealed structural characteristics of nuclei, and of nucleons shown by scattering the accelerator's beam of electrons from nuclei, protons and deuterons. Electrons have a characteristic dimension (the so-called de Broglie wavelength) which varies with their energy, such that the greater their energy the smaller their effective size. When accelerated in velocity until their energy is 1 Bev, they shrink in size to a de Broglie wavelength of about 0.2×10^{-13} cm., which is approximately the size of the proton and the neutron. Being of the same order in size, when they are scattered by nucleons, measurement of the angular distribution of the scattered electrons yields information regarding the electrical and magnetic structure of the particles with which they collided. In effect, the 1 Bev accelerator, 300 feet in length, is used as a tool with a very fine point for probing particles which are only 1/100,000,000,000,000,000 as large as the instrument.

This research is being continued under ONR and AFOSR sponsorship, and being expanded to include an ingenious experiment wherein two electron beams will be caused to collide.

TO OUR READERS:

This, the second issue of the OAR RESEARCH REVIEW, is being distributed widely on a one-time basis to key officers of the military services and other government agencies interested in research. The purpose of OAR in doing this is to provide them with insight as to some specific examples of Air Force sponsored basic research accomplishments. OAR's product serves the dual purpose of adding to the common fund of new knowledge available to the scientific community and providing the foundation upon which future weapon systems are developed.

Our continuing goal is to attempt to satisfy, through the REVIEW, the information needs of both scientist and the non-scientific decision-maker, since we feel each is of importance. It is inevitable that many decisions concerning basic research are made by people who are not scientists. We believe that it is important that these people be informed about research in progress, and understand something of its potentialities. It is equally important that the scientist be kept up-to-date on research projects occurring within his areas of interest.

Finally, as evinced by the special distribution of this specific issue, we believe it desirable that the key officers of today's services realize that the aerospace power of tomorrow will be forged from the basic research discoveries and new scientific information being given the world daily by the OFFICE OF AEROSPACE RESEARCH, its counterparts in other agencies, and the many scientists and researchers in the Free World who work under OAR grants and contracts.

Those of you among our readers who feel a need for further information about a topic covered in any issue are urged to contact the author or originating laboratory direct. Addresses for use on such occasions are shown on inside back cover.

Constructive criticism and suggestions for improvement will be most welcome, and should be directed to this headquarters, ATTN: RREI.

Daniel E. Hooks

DANIEL E. HOOKS
Major General, USAF
Commander

EXCERPTS FROM A REVIEW . . .
In the November 1961 AMS Notices of a book, published by The Princeton University Press of the Principal Addresses From the Conference on Analytic Functions Held during 2 - 14 September 1957 at the At the Institute for Advanced Study, Princeton, New Jersey And Sponsored by the Mathematical Sciences Directorate, AFOSR

R. G. POHRER, Mathematics Division, AFOSR

The American Mathematical Society's Notices of November 1961 contain a review which includes the following phrases:

"At first glance, it would appear that this book has no other motivation than the transcription of the principal addresses of the 1957 Conference on Analytic Functions. ...If this were the case, a review here of this book would be as ludicrous as a review of Vol. 71 of the Transactions*. But such is not the case. The book stands as an exposition of complex analysis in the last decade, and treats well and fully the lines of research developed in that period. The majority of articles meets the needs of those with an outside interest in complex analysis who are curious to understand the new results and techniques. More important, the new student of complex analysis is presented with the tools and bibliography which he needs and cannot find elsewhere. From the point of view then, of general information, this book differs from the journals and other colloquia volumes, and it is because of this that it is important...it is an important contribution to the exposition of modern mathematics. It is indeed time for more such books, in the same field as well as others"...Hugo Rossi.**

The point of the review is clear, and well taken. The point of repeating these excerpts here is to advise the world of the quality and attainment of the Air Force's basic research program in mathematics, of the developments and the communication of such developments which are our legitimate interest, and of the need for continued and expanded efforts in these directions.

* The journal, "Transactions of the American Mathematical Society."

**Professor Rossi, incidentally, was among the first to hold an AFOSR Fellowship under that special program.

Aeroballistics of Dual Rail Rocket Sleds

PROJECT 7856

FRIEDRICH H. UTECH, Science and Engineering Division , AFOSR

The simulation of the shock and vibration environment of advanced vehicles by means of captive flight tests has proven to be an important link in many missile system developments. The effects encountered can be successfully studied using dual rail rocket sleds. At present, these vehicles attain velocities up to approximately M = 1.5. An extension of this speed range toward higher Mach numbers will, undoubtedly, contribute to the advancement of the state of the art in this field.

To attain higher velocities, the aerodynamics of the sled motion must be studied in detail: Not only the drag increase is of importance; considerable lift forces also become generated at these speeds. The latter -- induced by the interference of the sled with the ground -- can approach or even exceed the drag loads, while the center of pressure is moved to extreme positions very inconvenient for a simple design. To exemplify the magnitude of forces encountered: The lift and drag of a conventional sled might easily reach 100,000 pounds when operated in the M = 3 range.

To obtain the necessary knowledge in this field, the Directorate of Research Analysis, AFOSR, has sponsored a contract with the University of Minnesota Rosemount Aeronautical Laboratories to conduct a fundamental study on the influence of ground interference. Basic sled design parameters such as, e.g., body contour, nose shape, position of the body with respect to the ground, location and contour of slipper beams, etc., were varied to determine their effects on sled aerodynamics. In this investigation, recourse has been taken primarily to wind tunnel testing; the attempt to assess the effects of the reflecting shock waves by analytical means has shown that only simple body contours in the presence of a plane ground could be treated with a reasonable amount of computational efforts.

Results were obtained for families of basic sled configurations having rectangular and circular cross-sections and different in width, height and position. The nose shapes have been varied systematically and the pertaining effects determined. The Mach number range covered extended from M = 0.8 to M = 4.0. Based on the experience gained during this study, the attempt has been made to develop such configurations which produce little or no lift, exhibit a favorable center of pressure location and have tolerable drag coefficients. The study shows that such designs are possible.

Three reports are available at the Directorate of Research Analysis, AFOSR, which provide the designer of rocket sleds with pertinent information. Some of the ideas proposed in these reports already have been

successfully applied in modern sled design. At present, the effects exerted on the slipper beams by ground-reflected shock waves are being studied. No details are known about this effect, but theoretical considerations indicate that positive, negative or zero lift forces are equally probable. Therefore, the study objective is to determine under what circumstances lift forces generated on slipper beams will balance the lift produced by the sled body, and whether they can be used as a means for attaining more desirable center of pressure locations of the whole sled configuration.

extreme response set

CHARLES E. HUTCHINSON, Life Sciences Directorate, AFOSR

Doctor E. F. Borgatta, AFOSR Grantee at the University of Wisconsin, has recently reported some results in the Journal of Social Psychology bearing on the problem of response set.

The research reported by Dr. Borgatta is of interest to the Air Force as one phase of a program of research directed toward understanding the behavior underlying performance in military organizations. This program is developing concepts and methods applicable to the selection and assignment of personnel, and in developing criteria useful in predicting performance in organizations.

It has been noted over a period of years that different styles of response characterize some individuals in answering questions on a personality inventory or test. A consistent pattern of responding to a variety of questions is called a response set. One of the more interesting response patterns is that called the Extreme Response Set or ERS. Some have considered the ERS to have personality correlates such as decisiveness, rigidity, or intolerance of ambiguity. Others have reported substantial relationships between ERS and clinical diagnosis of neuroses and psychosis.

Since the ERS is a consistent response not related to the specific content of the question (or stimulus item), it tends to cloud the differences in personality which the scales are designed to measure.

Borgatta has developed ERS scores for groups of subjects on the basis of one panel of tests, and he has correlated these ERS scores with the results obtained by the same subjects when tested on two standardized personality tests that measure different personality dimensions. In order to accentuate the personality differentials, Borgatta

utilized male and female subjects, and within each sex contingent were groups of college students, mental patients, and prisoners:

Subjects	Mean ERS Score	Rank
Male Mental Patients	18.71	1
Female Mental Patients	18.30	2
Female Prisoners	17.63	3
Female College Students	15.34	4
Male College Students	14.10	5
Male Prisoners	12.29	6

Results of this analysis, when arranged in descending order, provide evidence of a rather complex relationship. Mental patients of both sexes rank highest in ERS. Female prisoners and women college students are in the median positions, and male college students and male prisoners are lowest in frequency of extreme responses.

No attempt should be made at this stage to read more than statistical significance into these findings, particularly in the light of the inability of the investigator to produce more than a handful of significant correlations between ERS and specific personality traits as measured by the instruments. The uniformly high rank of mental patients suggests that mental disturbance may bear a unique relationship to ERS. Women are more apt than men to respond in an extreme fashion which correlates with earlier findings that anxious subjects have a higher ERS.

Borgatta notes that the tendency to extreme response tends to hide the real variability in personality that inventories are intended to measure, but he warns that "the findings of the present study raise a serious question as to the psychological meaningfulness of ERS."

MORE PRECISE LOCATION of LAND MASSES

Terrestrial Sciences Laboratory, AFCRL

The position assigned to Hawaii on our maps may be in error by as much as 400 ft. For other land areas, such as Johnson island which may figure prominently in future atmospheric atomic tests, the error may be as much as 800 ft.

AFCRL recently undertook a series of experiments that may improve the geodecist's precision in locating the positions and distances of land masses. These experiments involve AFCRL's rocket flash triangulation technique. The technique consists of ejecting high intensity flash cartridges into the night sky and simultaneously photographing these flashes against a star background by a number of highly accurate cameras located at widely scattered sites through the Pacific basin.

On December 8, an Astrobee 1500 sounding rocket was launched from the Naval Missile Facility at Point Arguello, California. The payload constructed at AFCRL consisted of three 7-flash "Poppy" pyrotechnic cartridges developed by the Army's Picatinny Arsenal at Dover, N. J. Each of the flashes was designed to produce a peak light output of 62 million candle power. The cartridges, programmed to eject in three groups of 7 during the rocket's flight, were timed to fire at altitudes of 900 miles, 1400 miles (apogee) and again at 920 miles during descent. The rocket's apogee point was about halfway between California and the Hawaiian Islands.

The objective of the technique, which is actually a photogrammetric extension of classical surveying principles from two into three dimensions, is to photograph the flashes and the star background simultaneously from at least two stations whose geodetic coordinates are accurately known, and from any number of sites treated as unknowns. Since the celestial coordinates of the stars are known very accurately, it is possible to "fix" the spatial coordinates of the flashes by intersection from the two known stations. It is then possible to compute the position of the other stations in terms of the known stations by determining the coordinates of the flashes and stars on the plates. If two or more plates are taken from each station utilizing separate sections of the star background, the position of the unknown station can be computed without knowledge of local gravity factors, thereby eliminating a significant source of error that is present in other surveying techniques.

Four sites in North America were used as the "known" stations. These were at Sitka, Alaska, Spokane, Washington, Lincoln and El Centro,

California. Two additional APCS-operated AFCRL cameras were located at Mauna Loa, Hawaii, and Kaena Point, Oahu to act as the primary unknown sites. Other sites were used to provide redundancy, to extend the technique for special purposes such as positioning a ship at sea, to determine if widely varying types of existing equipment could be used and to investigate atmospheric turbulence and refraction problems. During the rocket's flight, visual sightings of the flashes were observed from Hawaii, Johnston Island, Alaska and California.

several at one *BLOW*

B. R. AGINS, Captain, USAF, Applied Mathematics Division, AFOSR

The solutions to many modern scientific problems rely heavily on sorting.By sorting we mean selection of one object (i.e. the largest) from many,or permutation of a collection of objects into a given order.

The problem of sorting information on a digital computer, either internally or on auxiliary storage, such as magnetic tape, has generally been attacked from the programing point of view: How to devise an *EFFICIENT* algorithm (systematic procedure) for sorting on existing data processing machines. In a sense, this problem may be regarded as unsolvable for existing machines, since they lack simultaneous multiple access to memory and/or they lack direct means for permuting large numbers of words.

A large scale computational problem may involve many computations on solutions to 100,000 linear algebraic equations in as many unknowns. On a 100-microsecond multiply standard computer with adequate high-speed memory, a single computation would take about 10,000 hours. In view of these facts, the emphasis on ultrahigh-speed computers can be understood.

Let us consider just the one question of solving large sets of linear equations by iterative procedures. Suppose we have a large number of equations in the same number of unknowns, and that they are in a form such that the unknowns are on the left-hand side of each equation and a constant on the right.

In a typical iterative procedure, an initial guess is made of the value of the unknowns, which is substituted, and computed, which leads to a first approximation of the values. This first approximation is then substituted and a second approximation is obtained. The procedure is iterated until the approximations converge (i.e., the difference between successive approximations is less than a given

number). Convergence is quite slow under this procedure, so it is desirable to look for other methods.

Another iterative technique is a nonsystematic relaxation procedure. Again, an initial guess is made of the value of the unknowns and the equations evaluated, then the difference between the right- and left-hand sides of the equation is computed for each of the equations, and the largest difference selected. A next value of the unknowns is chosen to make this largest difference zero or almost zero. The process is iterated until the approximation converges. This procedure has rapid convergence, which means fewer computations, but a large number of comparisons, each of which requires time on a standard computer. For example, in a 10,000 point problem arising in the solution of Laplace's equation, a computer would have to make 9999 comparisons each time a largest difference is to be chosen. On existing single-address standard machines, this means going through an approximately 20 program step loop 9999 times each time an approximation is to be improved! This makes the second technique as time consuming as the first.

An alterative attack on the sorting problem is to develop an auxiliary sorting device which, like human computists, is capable of scanning a large collection of numbers and selecting the largest or ordering the numbers at a single scan.

Working under an AFOSR grant at Case Institute of Technology, Dr. R. J. Nelson has been investigating simple mathematical models of Turing machine type computers which simulate computists capable of scanning a linear array of symbols, and permuting them into natural order while scanning. The central problem is relating the number of passes through the machine to the number of symbols scanned. Dr. Nelson, working with Dr. R. C. Bose, considered sorting a sequence of n numbers into numerical order, and determined the upper bound for the number of comparisons needed to make the sort, and developed an algorithm for sorting n numbers (TN AFOSR 636). Dr. Nelson has proved that there are machines that order n symbols at one pass, but scan less than n symbols at once. He has proved that given a machine with h heads, it will sort n symbols at one pass, or require p passes to sort N symbols, when N is greater than n.

These proofs have been constructive in that the spacing between heads is determined. Dr. Nelson is now engaged in proving that this is the optimum spacing.

The results of this research open up new capabilities for computers. Computer time required may be reduced considerably, and problems now considered too time consuming for standard computers may well be solved on machines to be developed using these new methods. The importance of this work is indicated by the unusually large numbers of requests for reprints of the TN received from such companies as IBM, Burroughs, etc.

TRITIUM in solar flare material

Photochemistry Laboratory, AFCRL

Solar Flare gases may contain unsuspectedly large amounts of tritium. The large concentration of tritium was first observed by scientists of the Smithsonian Astrophysical Observatory after examining structural parts and components of Discoverer Satellite XVII, furnished them by AFCRL.

Although tritium (hydrogen 3) could be produced in these materials by bombardment by high energy particles, the Smithsonian group suspected that the concentration of tritium in the satellite parts was too high to be explained by particle bombardment alone. Precise data on the production of tritium by particle bombardment, however, was lacking.

Dr. J. T. Wasson of AFCRL, as a result of his study of the stainless steel structural parts of Discoverer XVII, has given a firm statistical basis for the rate of tritium production by alpha particle bombardment. His study shows that this rate falls far below the observed quantities. The large amounts of tritium found therefore was present in the solar flare material.

The Discoverer XVII satellite around which the tritium studies evolve, provided excellent clues to the content of the violently erupting solar gases. It was launched during the intense solar cosmic ray event of November 12, 1960. Large concentrations of tritium were found in the battery case and in some of the lead samples carried on the satellite. Although tritium can be produced by bombardment of lead by high energy protons from the sun, the amount of tritium found exceeded the quantity that would be produced by the bombardment by the known flux of solar protons alone.

A second explanation involved a so-called alpha stripping reaction. It was here that Dr. Wasson's study was focused. In this process, alpha particles (helium 4 nucleii) known to make up about five percent of flare particles, lose a proton to a target nucleus. The helium 4, thus becomes hydrogen 3, or tritium. The question that Dr. Wassen set out to answer was just how much tritium could be produced by this process.

Through the radiochemical analysis of stainless steel parts

of the missile he was able to provide a quantitive answer. Iron-56 is the basic isotope of the stainless steel used in the examination and comprised 64 percent of the total content of the stainless steel. If an alpha particle loses a proton to iron-56, cobalt-57 is produced. Thus, by examining the stainless steel for Cobalt-57 content and comparing this with the tritium content, he was able to show that the amount of cobalt-57 was lower by a factor of 20 than was tritium. Alpha stripping alone, therefore, could not have produced the tritium in the heavy concentrations measured. Dr. Wasson's study gave strong supporting evidence that the tritium detected was present in the solar flare material and was produced in the atmosphere of the sun.

B-58 ESCAPE CAPSULE STABILITY PROBLEM

OTTO WALCHNER, Hypersonic Research Branch (ARR), ARL

In the Fall of 1961, the B-58 System Program Office (ASZHP) interested ARL in difficulties related to the motion of the B-58 escape capsule upon separation from the aircraft. High g'loads on the occupant of the capsule can result from the capsule motion and give reasons for concern.

Part of these difficulties were traced back to the lack of stability in yaw during the time between separation and deployment of stabilizing devices, such as fins and chute. Without chute and with fins stowed, the B-58 capsule is statically unstable in yaw because of its rounded nose shape and the aft position of the center of gravity. An angle of sideslip develops, as a consequence of this instability in yaw. The asymmetry in shape then gives rise to a rolling moment due to sideslip. The key for the improvement of the capsule's dynamics is to provide adequate basic capsule stability in yaw, that is for the capsule with fins stowed.

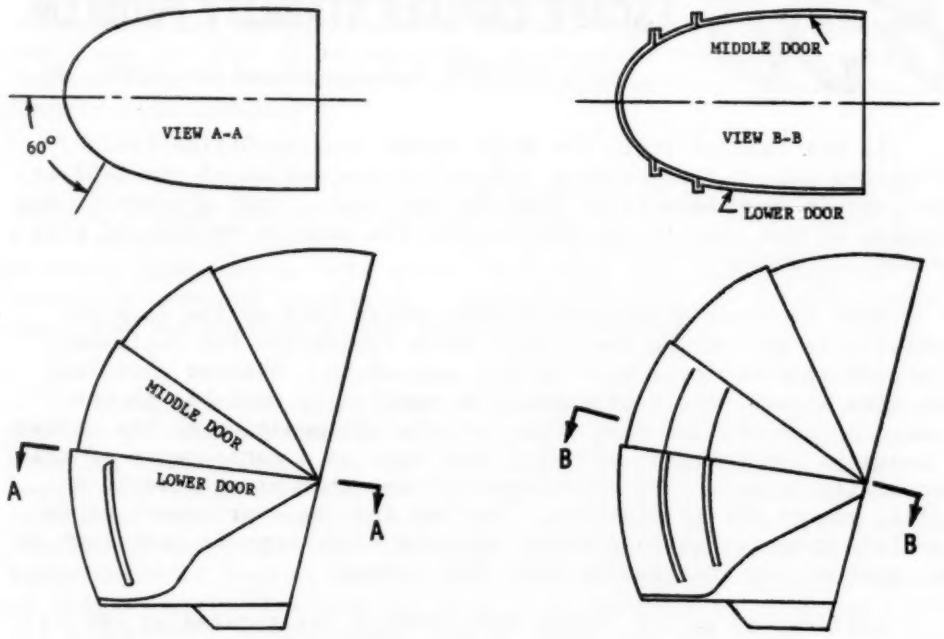
Application of the "Bluff Nose-effect" (originated at ARL in earlier years) could provide the required stability in yaw. This was successfully demonstrated by North American Aviation with the B-70 capsule configuration. However, a redesign of the B-58 capsule in this direction is not compatible with the program schedule, nor with the space available in the aircraft. Present trend, therefore, is to improve the capsule stability with small fixes.

To some degree, this has been done by adding spoilers to the side of the capsule nose. Qualitatively, these spoilers approximate the bluff nose effect. Quantitatively, their effect depends on location, orientation, length, width, number of spoiler pairs, Mach and Reynolds number. Convair and Stanley Aviation Co. have

investigated the effect of a pair of vertical spoilers fixed to the lower door, as seen in Fig. 1. The spoilers are directed perpendicular to the capsule surface and the investigation was made for two spoiler locations, 45 degrees and 60 degrees off the capsule centerline.

In a meeting on 21 November 1961, Air Force representatives and contractor personnel discussed spoiler results which were available at this time from wind tunnel tests and sled ejection tests. The results indicated significant gains in yaw stability by spoiler effects especially for the 60-degree spoiler arrangement. However, the capsule with fins stowed is still unstable.

B-58 ESCAPE CAPSULE WITH VERTICAL DOOR SPOILERS



ARL personnel, attending this meeting were given the opportunity to demonstrate in a small wind tunnel at low speed the effects of other spoiler configurations on static and dynamic stability of a 1/12 scale finless capsule model having one degree of freedom to pitch, roll or yaw. Emphasis was put on yaw stability and the following spoiler effects were pointed out at this presentation.

The improvement of the static stability in yaw by spoilers results from flow separation enforced by the spoiler. The extension of the zone of separated flow is of importance. For a given spoiler configuration, the extension of the flow-separation increases with

Mach number at subsonic speeds and reaches a maximum at transonic speeds. At supersonic speeds, however, the extension of the flow separation past spoilers is shorter than at transonic speeds and is more nearly comparable with that for incompressible flow conditions.

For this reason, a stability study at low Mach numbers is considered to be of value although this Mach number does not represent the actual flight regime of the capsule. One may conjecture that a spoiler configuration which gives satisfactory stability in yaw at low subsonic speeds, will be satisfactory also at high subsonic and supersonic speeds. On the other hand, a spoiler configuration giving satisfactory results at transonic speeds (such as noticed during a recent airborne capsule ejection from a B-58 aircraft at Mach 0.8, December 1961) will not necessarily be satisfactory at supersonic speeds.

Static stability in yaw can be obtained by the use of spoilers for a limited range of angles of sideslip only. If for any reason the angle of sideslip exceeds this threshold value, the static stability of the finless capsule is lost again.

The most effective spoiler configuration evolving from the ARL low speed study had the following characteristics. Two pairs of vertical spoilers were found necessary to provide static stability in yaw for the finless capsule. The best orientation of the spoilers was parallel to the capsule y - axis and not perpendicular to the capsule surface. The vertical spoilers were found to be more effective if their length is increased beyond the height of the lower door. To make folding of the doors possible, the lower door spoiler should be built as a pocket into which the spoiler fixed to the middle door can immerse (Fig. 2). The front spoiler pair should be located at the position of the present 60-degree spoiler. The distance between front spoiler and rear spoiler is critical and should be determined for supersonic conditions. This distance also depends on the width of the spoilers.

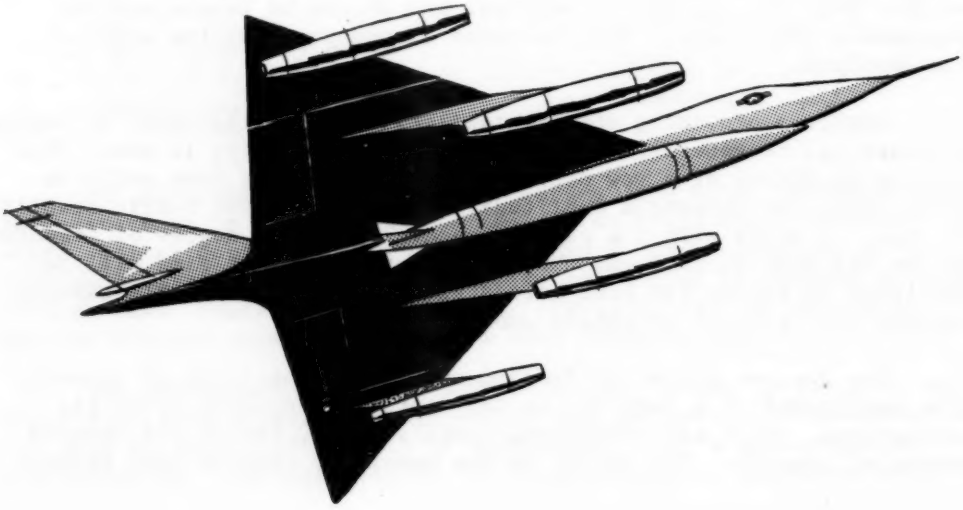
Spoilers providing static stability in a limited range of angles of sideslip, in general, introduce dynamic instability in yaw. That is, the amplitude of a yaw oscillation will increase from cycle to cycle until the threshold amplitude is reached and the static stability is lost. A study with the capsule model having one degree of freedom in yaw was made to find out whether or not sufficient time will be available to deploy the fins before the dynamically unstable capsule reaches the critical threshold amplitude in yaw.

For the one degree of freedom condition, the ratio of consecutive amplitudes is a function of the static and dynamic stability derivatives, which are aerodynamic coefficients, and of the reduced moment of inertia. The latter is the moment of inertia with respect

to the yaw axis, divided by the air density and the fifth power of an arbitrarily chosen reference length. Disregarding Mach number and Reynolds Number effects, the aerodynamic coefficients are identical for model and prototype, because they depend on the configuration only. Therefore, model and prototype will show the same ratio of successive amplitudes, if the values of the reduced moment of inertia are identical, also. The latter increases with altitude, because of the decreasing air density. The higher the value of the reduced moment of inertia, the smaller the increment of amplitude from cycle to cycle. Consequently, the model investigated was ballasted so as to simulate the most critical conditions, that is sea level altitude.

The time was observed which the model needed to build up the yaw amplitude from an initial small disturbance to the value of the threshold amplitude. With the proper time scale applied, it was found that the stabilization frame with fins can safely be deployed - it takes less than 0.5 seconds to do so - before the inherent dynamic instability causes the capsule to yaw excessively.

The study described above represents a limited contribution to the spoiler problem at hand. A great variety of spoiler configurations was investigated in an economical way and an optimum was found for low subsonic Mach numbers and low Reynolds numbers by dynamic tests restricted to one degree of freedom. ARL personnel feel that the presented results can be used for the formulation of a promising wind tunnel program at higher Mach and Reynolds numbers. It is expected that ARL personnel will continue to consult with the B-58 System Program Office and the Air Force contractors about this problem.



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